

## WHAT IS CLAIMED IS:

1. A semiconductor laser device comprising:  
an active layer;

5 a first cladding layer of a first conduction type provided  
on said active layer;

a current blocking layer of a second conduction type  
provided on said first cladding layer except a current  
injection region;

10 a low carrier concentration layer provided on the side  
of said current blocking layer between said first cladding  
layer and said current blocking layer and having a lower carrier  
concentration than said current blocking layer; and

15 a depletion enhancement layer provided on the side of  
said first cladding layer between said first cladding layer  
and said current blocking layer for inhibiting storage of  
carriers in said low carrier concentration layer.

2. The semiconductor laser device according to claim 1,  
20 wherein

the band gaps of said first cladding layer, said depletion  
enhancement layer and said low carrier concentration layer are  
reduced in this order.

25 3. The semiconductor laser device according to claim 1,

wherein

said first cladding layer has a flat portion formed on said active layer and a ridge portion formed on said flat portion in said current injection region,

5        said depletion enhancement layer is formed on said flat portion located on both sides of said ridge portion and on the side surfaces of said ridge portion, and

10        said low carrier concentration layer and said current blocking layer are successively formed on said depletion enhancement layer.

4. The semiconductor laser device according to claim 3, wherein

15        the thickness of said depletion enhancement layer is at least 10 nm.

5. The semiconductor laser device according to claim 4, wherein

20        the thickness of said depletion enhancement layer is at least 15 nm.

6. The semiconductor laser device according to claim 1, further comprising a ridge-shaped second cladding layer of a first conduction type provided on said depletion enhancement layer in said current injection region, wherein

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said depletion enhancement layer is formed on said first cladding layer, and

said lower carrier concentration layer and said current blocking layer are successively formed on said depletion enhancement layer located on both sides of said second cladding layer and on the side surfaces of said second cladding layer.

7. The semiconductor laser device according to claim 1, wherein

10       said depletion enhancement layer, said low carrier concentration layer and said current blocking layer are successively formed on said first cladding layer except said current injection region,

15       said semiconductor laser device further comprising a second cladding layer of a first conduction type provided to fill up a space enclosed with the side surfaces of said depletion enhancement layer, said low carrier concentration layer and said current blocking layer and the upper surface of said first cladding layer in said current injection region.

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8. The semiconductor laser device according to claim 6, wherein

the thickness of said depletion enhancement layer is at least 15 nm.

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9. The semiconductor laser device according to claim 8,  
wherein

the thickness of said depletion enhancement layer is at  
least 20 nm.

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10. The semiconductor laser device according to claim  
7, wherein

the thickness of said depletion enhancement layer is at  
least 15 nm.

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11. The semiconductor laser device according to claim  
10, wherein

the thickness of said depletion enhancement layer is at  
least 20 nm.

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12. The semiconductor laser device according to claim  
1, wherein

said depletion enhancement layer has a single-layer  
structure or a superlattice structure.

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13. The semiconductor laser device according to claim  
1, wherein

said active layer includes a layer made of  $(\text{Al}_{x_1}\text{Ga}_{1-x_1})_{y_1}\text{In}_{1-y_1}\text{P}$ ,

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said depletion enhancement layer is made of  $(\text{Al}_{x_2}\text{Ga}_{1-x_2})_{y_2}\text{In}_{1-y_2}\text{P}$ .

$\text{Al}_{x_2}\text{In}_{1-y_2}\text{P}$  or  $\text{Al}_{x_2}\text{Ga}_{1-x_2}\text{As}$ ,

said low carrier concentration layer is made of

$(\text{Al}_{x_3}\text{Ga}_{1-x_3})_{y_3}\text{In}_{1-y_3}\text{P}$  or  $\text{Al}_{x_3}\text{Ga}_{1-x_3}\text{As}$ ,

said current blocking layer is made of  $(\text{Al}_{x_4}\text{Ga}_{1-x_4})_{y_4}\text{In}_{1-y_4}\text{P}$

5 or  $\text{Al}_{x_4}\text{Ga}_{1-x_4}\text{As}$ , and

said  $x_1$ , said  $x_2$ , said  $x_3$ , said  $x_4$ , said  $y_1$ , said  $y_2$ ,

said  $y_3$  and said  $y_4$  are at least zero and not more than 1

respectively.

10 14. The semiconductor laser device according to claim 1, wherein

said active layer includes a layer made of  $\text{Al}_{x_1}\text{Ga}_{1-x_1}\text{As}$ ,

said depletion enhancement layer is made of  $\text{Al}_{x_2}\text{Ga}_{1-x_2}\text{As}$ ,

said low carrier concentration layer is made of

15  $\text{Al}_{x_3}\text{Ga}_{1-x_3}\text{As}$ ,

said current blocking layer is made of  $\text{Al}_{x_4}\text{Ga}_{1-x_4}\text{As}$ , and

said  $x_1$ , said  $x_2$ , said  $x_3$  and said  $x_4$  are at least zero

and not more than 1 respectively.

20 15. The semiconductor laser device according to claim 1, wherein

said active layer is made of  $\text{In}_{x_1}\text{Ga}_{1-x_1}\text{N}$ ,

said depletion enhancement layer is made of  $\text{Al}_{x_2}\text{Ga}_{1-x_2}\text{N}$ ,

said low carrier concentration layer is made of

25  $\text{Al}_{x_3}\text{Ga}_{1-x_3}\text{N}$ ,

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said current blocking layer is made of  $\text{Al}_{x_4}\text{Ga}_{1-x_4}\text{N}$ , and  
 said  $x_1$ , said  $x_2$ , said  $x_3$  and said  $x_4$  are at least zero  
 and not more than 1 respectively.

5           16. The semiconductor laser device according to claim  
 1, wherein

said active layer includes a layer made of  $(\text{Al}_{x_1}\text{Ga}_{1-x_1})_{y_1}\text{In}_{1-y_1}\text{P}$ ,

10           said depletion enhancement layer is made of  $(\text{Al}_{x_2}\text{Ga}_{1-x_2})_{y_2}\text{In}_{1-y_2}\text{P}$ ,

said low carrier concentration layer is made of  
 $\text{Al}_{x_3}\text{Ga}_{1-x_3}\text{As}$ ,

said current blocking layer is made of  $\text{Al}_{x_4}\text{Ga}_{1-x_4}\text{As}$ ,

15           said  $x_1$ , said  $x_2$ , said  $x_3$ , said  $x_4$ , said  $y_1$  and said  $y_2$   
 are at least zero and not more than 1 respectively, and

said first conduction type is the p type, and said second  
 conduction type is the n type.

20           17. A semiconductor laser device comprising:

an active layer;

a first cladding layer of a first conduction type provided  
 on said active layer;

25           a first current blocking layer having a low carrier  
 concentration provided on said first cladding layer except a  
 current injection region; and

a depletion enhancement layer formed between said first cladding layer and said first current blocking layer for inhibiting storage of carriers in said first current blocking layer, wherein

5        said depletion enhancement layer has an energy level in band gap supplying second conduction type carriers to compensate for first conduction type carriers supplied from said first cladding layer due to a modulation doping effect.

10        18. The semiconductor laser device according to claim 17, wherein

      said first current blocking layer has a narrower band gap than said first cladding layer.

15        19. The semiconductor laser device according to claim 17, wherein

      said energy level in band gap has such density that substantially all said band-to-band levels ionize under a condition applying no bias voltage.

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      20. The semiconductor laser device according to claim 17, wherein

      said energy level in band gap is formed by doping with a second conduction type impurity.

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21. The semiconductor laser device according to claim 17, wherein

the material of said depletion enhancement layer is the same as the material of said first current blocking layer.

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22. The semiconductor laser device according to claim 17, wherein

said first cladding layer has a larger band gap than said depletion enhancement layer,

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said semiconductor laser device further comprising an intermediate band gap layer provided between said first cladding layer and said depletion enhancement layer and having a band gap smaller than the band gap of said first cladding layer and larger than the band gap of said depletion enhancement

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layer.

23. The semiconductor laser device according to claim 17, wherein

said depletion enhancement layer has a band gap smaller than the band gap of said first cladding layer and larger than the band gap of said first current blocking layer.

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24. The semiconductor laser device according to claim 17, wherein

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said first cladding layer has a flat portion formed on

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said active layer and a ridge portion formed on said flat portion in said current injection region,

said depletion enhancement layer is formed on said flat portion located on both sides of said ridge portion and on the side surfaces of said ridge portion, and

said first current blocking layer is formed on said depletion enhancement layer.

25. The semiconductor laser device according to claim 17, wherein

said depletion enhancement layer and said first current blocking layer are successively formed on said first cladding layer except said current injection region,

said semiconductor laser device further comprising a second cladding layer of a first conduction type provided to fill up a space enclosed with the side surfaces of said depletion enhancement layer and said first current blocking layer and the upper surface of said first cladding layer in said current injection region.

26. The semiconductor laser device according to claim 17, wherein

said depletion enhancement layer is formed on a region excluding said current injection region.

27. The semiconductor laser device according to claim 17, further comprising a second current blocking layer of a second conduction type provided on said first current blocking layer.

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28. A semiconductor laser device comprising:

an active layer;

a first cladding layer of a first conduction type provided on said active layer;

10 a first current blocking layer having a low carrier concentration provided on said first cladding layer except a current injection region; and

a depletion enhancement layer formed between said first cladding layer and said first current blocking layer for  
15 inhibiting storage of carriers in said first current blocking layer.

29. The semiconductor laser device according to claim 28, wherein

20 said first current blocking layer having a low carrier concentration has a narrower band gap than said first cladding layer.

30. The semiconductor laser device according to claim  
25 28, wherein

the band gaps of said first cladding layer, said depletion enhancement layer and said first current blocking layer having a low carrier concentration are reduced in this order.

5           31. The semiconductor laser device according to claim 28, wherein

          said first cladding layer has a flat portion formed on said active layer and a ridge portion formed on said flat portion in said current injection region,

10           said depletion enhancement layer is formed on said flat portion located on both sides of said ridge portion and on the side surfaces of said ridge portion, and

          said first current blocking layer having a low carrier concentration is formed on said depletion enhancement layer.

15           32. The semiconductor laser device according to claim 28, further comprising a ridge-shaped second cladding layer of a first conduction type provided on said depletion enhancement layer in said current injection region, wherein

20           said depletion enhancement layer is formed on said first cladding layer, and

          said first current blocking layer having a lower carrier concentration is formed on said depletion enhancement layer located on both sides of said second cladding layer and on the  
25 side surfaces of said second cladding layer.

33. The semiconductor laser device according to claim 28, wherein

5 said depletion enhancement layer and said first current blocking layer having a low carrier concentration are successively formed on said first cladding layer except said current injection region,

10 said semiconductor laser device further comprising a second cladding layer of a first conduction type provided to fill up a space enclosed with the side surfaces of said depletion enhancement layer and said first current blocking layer having a low carrier concentration and the upper surface of said first cladding layer in said current injection region.